

Early theories of the universe – A Taste

([NONS!](#)) ([The Care System](#)) ([Family Values](#)) ([Horror Movies Home](#)) ([GTF](#)) ([Apostrophes](#)) ([Can Eastern](#)) ([Bolson d'été](#)) ([Action Movies](#)) ([Cult Classics](#)) ([Twin Zone](#)) ([Links](#)) ([Paleontology](#)) ([X](#)) ([Miscellaneous](#)) ([Themes to Mont](#)) ([Sitemap](#))



PLATO AND EARLY GREEK PHILOSOPHERS

The early writings of Greek philosophers were perhaps the first attempts to understand the workings of the universe, and whilst they did not rely on modern experimentation as modern day scientists do, they did take a huge step in that direction by rejecting religious explanations and dismissing the causes of daily phenomenon's at the hands of the gods. They argued for example that lightning bolts were not hurled to the ground by an angry Zeus, but rather a natural product that could be rationally explained. A philosopher called **Lucretius**, writing in the first century BC stated that 'Nature is free and uncontrolled by proud masters and runs the universe by herself without the aid of gods.' Whilst these early theorists acknowledged the fact that the universe was not run by gods, but rather nature, they maintained the fact that gods still existed, with nature running independently of the divine.

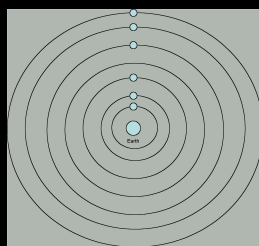
Of course the Greek philosophers came up with numerous theories as to how the universe works. For **Anaximander** we live inside a huge sphere with fire along the outside rim – the sun is nothing but a hole in the sphere through which we can see the fire!! However one particular model captured the imagination of the western world well into the 1600s. This was a version that was described by Aristotle, who took his assumptions from the teachings of Plato, and philosophers and scientists alike would embrace such a theory for centuries to come.

Plato was born in 427 BC and grew up during the Peloponnesian war. He earned much of his philosophy in the marketplace, where amongst others **Socrates** preached, telling them to question the morals they had been taught. For Socrates this resulted in him being sentenced to death as the community elders were not happy. Given the death of his friend and the ongoing war Plato sought absolute truths with the aim of bringing order to his life. His universe depended on perfections (only in our own minds can a circle be perfect – draw one and it may be slightly off). He picked five ideal shapes and claimed that the elements matched them: fire was a tetrahedron (a 3 sided pyramid), earth a solid cube, air an octahedron and water a twenty sided icosahedron. The planets he believed must travel in circles with a uniform motion. Whilst there was little evidence to suggest this to be true, even the planets zig zagged across the sky, Plato thought it to be a beautiful theory and so true!!

Plato's blindness did not however come from an inability to see but his disdain for what he saw. He chose to ignore what he saw and created a theory of the universe with everything moving in these perfect circles – and then he asked others to formulate a mathematical model that would fit it. **Eudoxus**, one of Plato's pupils, rose to the challenge and described a set of planets sitting on a series of moving spheres with the earth as their center. The sun for example had three spheres, one to move around the earth daily, another slower sphere, which on an annual basis moved to account for the way the sun appears to move higher in the sky throughout the seasons, and a third sphere to explain some incorrect observations of the time that had the sun changing position on the horizon from equinox to equinox. Eudoxus described each planet this way, adding on spheres moving at different speeds and in different directions, until there were twenty seven spheres in total.

The model was of course totally inaccurate, but the concept itself was mind boggling. For the first time someone had produced a mathematical model which correlated to what he saw. whilst the model didn't perfectly fit the data you could use it to predict where a planet should be with reasonable accuracy. Effectively math corresponded to reality. When we see that math correlates to reality it forces one to believe that the model is correct, and therefore it is important for scientists to remember how false theories such as this one have been emphatically believed in the past.

Indeed this theory, with the help of **Aristotle**, would be believed for centuries as inecently that we believe today that the earth goes round the sun. Aristotle himself added a twist to Eudoxus's theory, he turned those ephermal spheres into something solid. Aristotle studied under Plato for some twenty years before founding his own academy. He was born in northern Greece in 384 BC and inherited Plato's incorrect assumption that the planets move in circles. He built upon these views and stated that 'the shape of the heavens must be spherical. That is most suitable to its substance, and is the primary shape in nature.' The spheres in Aristotle's cosmology stemmed from Eudoxus's, but they needed re-working to become reality. He therefore devised a system whereby each sphere forced the spheres inside to rotate with it. Consequently he had to add spheres not only to account for the oddities of each planet's rotation but also to negate movement from the sphere above it. In the end his version had fifty five concentric, crystalline spheres and roughly accounted for most celestial movements. However it failed to answer a few key questions, including why the planets periodically shone brighter and larger, as if they had swung closer to us....



Aristotle's universe

Despite such short comings this didn't seem to affect its popularity, and his description of the universe caught the imagination of mankind. This is the way it works – Everything on earth is made of the four elements of earth, air, fire and water. All these elements seek to be at rest at their natural state, earth and water by moving in a straight line to the centre of the earth, and fire and air naturally moves in a straight line up. A rock that moves horizontally, say by being thrown in the air, does so only because an outer body has forced unnatural motion upon it. At the beginning of time all of the water and earth naturally fell down towards the centre of the universe, clumped together and formed the spherical globe that is the earth. This would automatically imply that there are no other universes as there would be two conflicting downs. Away from our atmosphere everything changed...the universe was made of a heavenly material called ether, which naturally moved in circles....perfect circles that is. There were spheres for the moon, the sun, the planets...and then beyond that was an unmoved mover, the divine force that moved the outer sphere that set each of the next fifty five moving. whilst Aristotle created a cosmology that did not require divine intervention, he insisted upon it!

Whilst Aristotle's cosmology became dogma one other ancient philosopher gave the grounding to make this theory stable. Aristotle's spheres still didn't correspond well to everything observed, producing a mechanical model took a true mathematician, **Ptolemy**.

He knew that as the planets moved around the earth they appeared to stop and go backwards for a while. To account for this Ptolemy added a twist to the orbits, claiming that each planet moved in tight little circles, and it was the very centre of this circle that moved in a gigantic circular orbit around the earth. This little extra orbit was labeled an epicycle. His model corresponded quite well with what we see. The biggest weakness in Ptolemy's model was his complicated description of Mars. Mars, orbiting the sun so close to us, has the hardest path to pin down if you are afflicted with an incorrect theory. Mars just refuses to move in perfect circles and Mars therefore was destined to be the first nail in the coffin for both Ptolemy and Aristotle.

Brahe (born 1546) and **Kepler** (born 1575) were two individuals who worked together during the 1600s, Brahe's observations of the universe were unsurpassed throughout the world and Kepler was a brilliant mathematician – and so whilst the relationship between the two was at times volatile, at the same time they needed each other. After one such altercation Brahe asked Kepler to describe the orbit of Mars, knowing full well that the greats of history had long since struggled and failed to come up with anything. Whilst Kepler was confident enough to say 'give me a week' it actually took him eight years, but when he eventually did it turned Ptolemy's model on its head. Until someone decided to map the orbit of Mars first, and then determine the math that described it theories would prove to be inaccurate, yet Brahe and Kepler nudged cosmology closer to the science we know by rectifying this mistake.

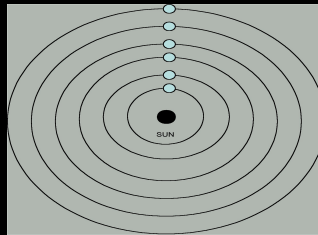
One night after dinner Brahe looked up at the sky and noticed a new star smack in the middle of the constellation Cassiopeia, and for the following few weeks it was even visible throughout the daytime. Over the next year and a half it faded and eventually disappeared...he had witnessed a supernova, the gigantic explosion that occurs during a star's last death throes...whilst he didn't know that he had witnessed such an event. All he knew was that he had witnessed the impossible, the perfect ever constant starry sky had just changed. The next time he saw a comet he took measurement, and presented the argument that this comet was far above the moon (below the moon was the only place where such changes, other comets, could have been possible) and so there was not just a change in the heavens but a body slicing right through Aristotle's crystalline celestial spheres. With the level of detail presented Brahe's destruction of the Aristotelian universe was hard to reject. This was one of his major contributions to cosmology, but his largest maybe his incredible attention to detail.

However Brahe was also a slave to his pre-conceptions. Unable to convince himself that the earth moved and unable to make his observations match a geocentric universe, Brahe recorded a solar system in which the sun and the moon orbited the earth, whilst all the other planets revolved around the sun.

It was at university that Kepler first discovered **Copernicus**, learning of a sun-centred world from his mentor Mastlin. So it was Kepler who was one of the first astronomers to be thoroughly indoctrinated in a heliocentric universe—he never doubted that the sun stood still whilst the earth rotated around it. Whilst taking up post as a maths teacher Kepler had a flash of inspiration. For years he had long wrestled with the question of why there were six planets, not five and not seven. However as he stood in front of his class one day he thought that the planets themselves might be organized according to the five platonic ideal shapes. First came Mercury's circular orbit, imagine an octahedron positioned around that circle the way any regular shape can be snugly fit around a sphere. Put another sphere around that and you get the orbit for Venus. Next an icosahedron, the sphere of the earth's orbit, then a dodecahedron, Mars, then a pyramid, Jupiter, then a cube, and finally Saturn. This pretty arrangement of geometry now showed why each planet's orbit was just so far out and no further.

As it happened the ratios among the planets didn't perfectly match up to the ratios of the solids, and we now know that there are more than six planets. We also know that invoking the platonic solids as a logical reason for why there were six doesn't make much sense to begin with. Brahe invited Kepler to work with him in 1600. Upon studying Brahe's details of the martian orbit, Kepler realised that the planet did not move at a constant speed, yet it was not until years later that Kepler had to face facts—Aristotle's perfect circles must go. Kepler showed that the planets moved in egg-shaped oval, in ellipses. Many ignored such an idea, including Galileo Galilei, the only other contemporary scientist who believed that the earth revolved around the sun.

The earth-centred universe of Aristotle and Ptolemy held sway on western thinking for almost 2000 years. Then in the 16th century a new idea was proposed by the Polish astronomer Nicolai Copernicus (1473 – 1543). He proposed that the sun, not the earth, was at the centre of the solar system. He called this model a heliocentric system, and in this new ordering the earth is just another planet, and the moon orbits the earth rather than the sun.



The Copernicus Universe

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